EG&G ROCKY FLATS

Technical Memorandum No. 1 Development of Corrective/Remedial Action Objectives for Operable Unit No. 2

U.S. Department of Energy
Rocky Flats Environmental
Technology Site
Golden, Colorado

Final
Revision 2

January 1995

RF/ER-94-0015.UN

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
BRA	Baseline Risk Assessment
CCR	Colorado Code of Regulations
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS/FS	Corrective Measures Study/Feasibility Study
COC	Chemical of Concern
C/RAO	Corrective and Remedial Action Objective
CT	Central Tendency
DCG	Derived Concentration Guideline
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site
LHSU	Lower Hydrostratigraphic Unit
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	Minimum Detection Limit
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priority List
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SVOC	Semivolatile Organic Compound
TBC	To-Be-Considered
TC	Toxicity Characteristics
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substances Control Act
UCL	Upper Confidence Level
UHSU	Upper Hydrostratigraphic Unit
UTL	Upper Threshold Limit
VOC	Volatile Organic Compound
WQCC	Water Quality Control Commission

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1.0 INTRODUCTION

Various areas of the Rocky Flats Environmental Technology Site (RFETS) are being remediated in accordance with provisions of the 1991 Interagency Agreement (IAG) between the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the State of Colorado (State) (IAG, 1991). As outlined in Section IX.A.1 of the IAG Statement of Work, Corrective and Remedial Action Objectives (C/RAOs) are to be developed to identify the contaminants and media of interest, exposure pathways and receptors, and acceptable contamination levels or ranges of levels for each exposure route. This technical memorandum is intended to fulfill these requirements for Operable Unit No. 2 (OU2) by establishing C/RAOs that are protective of human health and the environment.

The primary focus of this technical memorandum is to present preliminary remediation targets that have been selected to control the residual risk to human health and the environment. The OU2 human health chemicals of concern (COCs) for which contaminant-specific remediation targets were established are presented in Technical Memorandum No. 9 (DOE, 1994a). The COCs for environmental receptors are currently being developed. Background concentrations, potential chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs), and preliminary risk-based remediation goals (PRGs) were considered in establishing remediation targets for OU2.

The OU2 remediation targets will form the basis for evaluating remedial technologies while the Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Baseline Risk Assessment (BRA) and Environmental Evaluation are being completed. The OU2 remediation targets are intended to be protective of human health and the environment; however, they may not necessarily be the final clean-up standards that are selected as part of the Record of Decision (ROD).

Only preliminary remediation targets can be established prior to fully assessing the risks associated with OU2; however, the concurrent Remedial Investigation/Feasibility Study (RI/FS) approach adopted for this technical memorandum is consistent with the procedures outlined in Section 300.430(e)(2) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Specifically, 40 CFR 300.430(e)(2)(i) states that, "[I]nitially, preliminary remediation goals are developed based on readily available information, such as chemical-specific ARARs or other reliable information. Preliminary remediation goals should be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected." Using programmatic exposure scenarios also expedites the overall remedial schedule for OU2 by allowing the Corrective Measures Study/Feasibility Study (CMS/FS) to proceed through early identification of data needs to support the development of potential remedial alternatives. Should the final BRA and/or Environmental Evaluation indicate that the remediation targets selected for OU2 are not representative of the actual risk posed by the contaminated media, the required changes will be incorporated as early as possible during the development of the CMS/FS.

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This technical memorandum contains five sections, including this introduction, plus two appendices. Section 2.0 provides background information regarding remediation areas that represent OU2 contaminated media. A discussion regarding the identification of COCs for OU2 is presented in Section 3.0. The development of C/RAOs is discussed in Section 4.0 and the development of remediation targets for OU2 is described in Section 5.0. Appendix A contains the exposure factors used for calculating PRGs. Appendix B contains contaminant-specific toxicity information.

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2.0 REMEDIATION AREAS

OU2 is one of 16 operable units at the RFETS and, as shown in Figure 2-1, OU2 is located on the southeastern side of the RFETS industrial area. OU2 contains 22 Individual Hazardous Substance Sites (IHSSs) that have been organized into five remediation areas based on dissimilarities of contaminated media. These five remediation areas include source areas for surface soil contamination, source areas for subsurface soil contamination (potential or current), residual surface soil contamination, residual subsurface soil contamination, and Upper Hydrostratigraphic Unit (UHSU) ground water contamination. Brief summaries of the nature and extent of contamination for each of these five remediation areas are discussed below. The locations of the individual IHSSs associated with OU2 are shown on Figure 2-2. A matrix identifying the individual IHSSs in relation to the five remediation areas is presented in Table 2-1. Additional information regarding the IHSSs in OU2 can be found in *Phase II RFI/RI Report 903 Pad, Mound and East Trenches Area Operable Unit No. 2 - Preliminary Draft* (DOE, 1993).

2.1 Source Areas for Surface Soil Contamination

Source areas for OU2 surface soils have been defined as localized areas of elevated contaminant concentrations that may represent or have historically acted as sources of contamination. The 903 Pad Lip Site (IHSS 155) has been identified as a source area for elevated concentrations of radionuclides in surface soil. The 903 Pad Lip Site is located adjacent to the 903 Drum Storage Site and contains plutonium-239/240 and americium-241 that has remained after Drum Storage Site drum removal and cleanup activities. Other surface soil areas within and outside of the OU2 boundaries have become radiologically contaminated as a result of prior activities that occurred at the Drum Storage Site and the subsequent redistribution of contamination. The 903 Pad Lip Site may be a likely candidate for a non-time critical removal action.

2.2 Source Areas for Subsurface Soil Contamination

Source areas for OU2 subsurface soil contamination have been defined as IHSSs which were used as storage or disposal sites for low-level, hazardous, or mixed wastes. These areas may or may not currently contain waste material (e.g., spent solvents, cutting oils, drums). Additional field characterization efforts have been initiated to better quantify the nature and extent of contamination at these source areas. Subsurface soil source areas for OU2 include the 903 Pad Drum Storage Site, the Mound Site, and Trenches T-1 through T-13. These subsurface soil source areas may also be likely candidates for non-time critical removal actions.

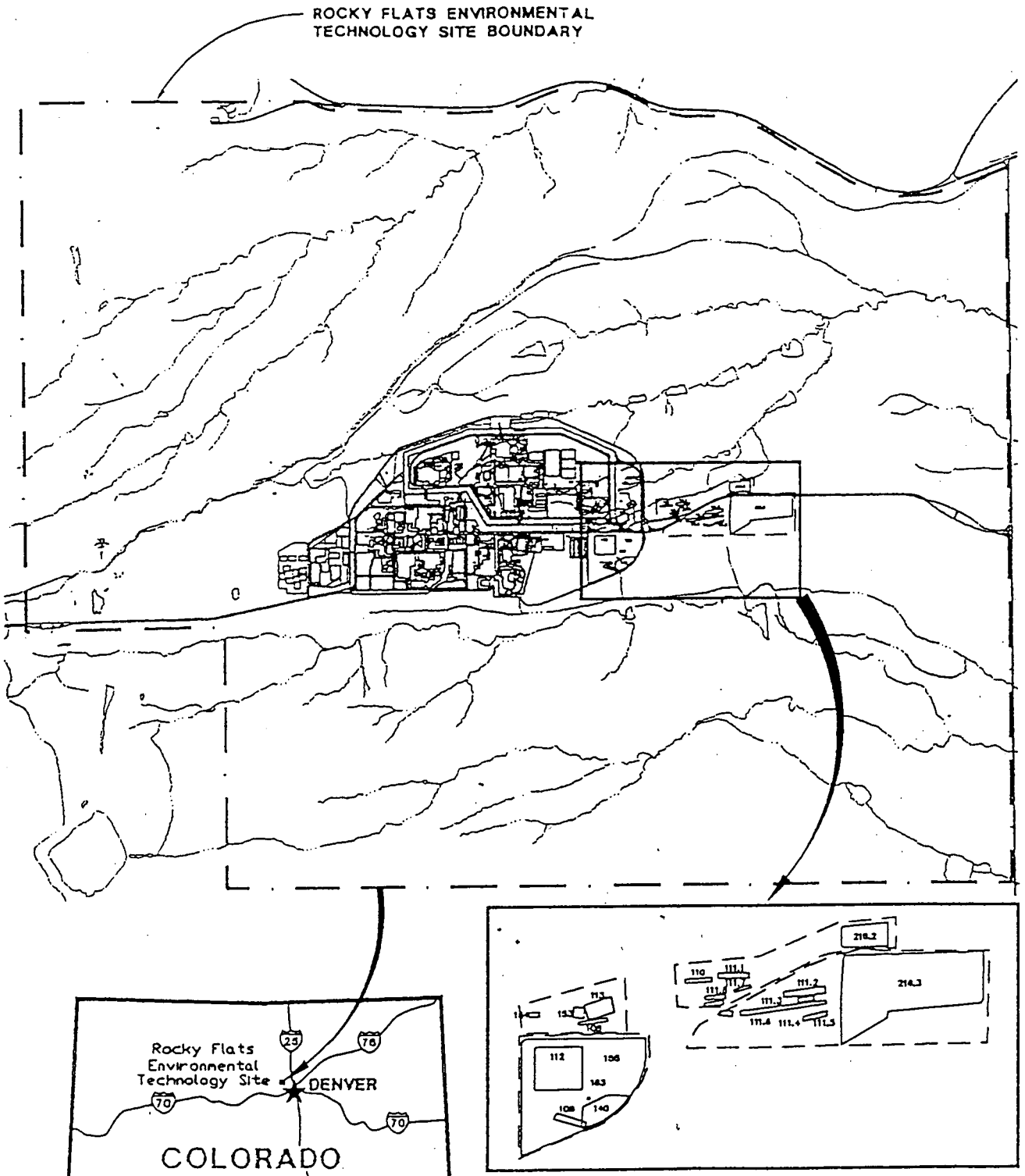

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Figure 2-1

Operable Unit No. 2
Technical Memorandum No. 1
Location Map

TABLE 2-1
IHSSs ASSOCIATED WITH OU2

IHSS	OU2 REMEDIATION AREAS [a]			
	SOURCE AREAS FOR SURFACE SOIL CONTAMINATION	SOURCE AREAS FOR SUBSURFACE SOIL CONTAMINATION	RESIDUAL SURFACE SOIL CONTAMINATION	RESIDUAL SUBSURFACE SOIL CONTAMINATION
903 Pad Drum Storage Site (112)		X		X
903 Pad Lip Site (155)	X		X	X
East Spray Fields (216.2)			X	
East Spray Field (216.3)			X	
Gas Detoxification Site (183)			X	
Mound Site (113)		X	X	X
Oil Burn Pit No. 2 Site (153)			X	
Pallet Burn Site (154)			X	
Reactive Metal Destruction Site (140)			X	
Trench T-1 (108)		X	X	X
Trench T-2 (109)		X	X	X
Trench T-3 (110)		X	X	X
Trench T-4 (111.1)		X	X	X
Trench T-5 (111.2)		X	X	X
Trench T-6 (111.3)		X	X	X
Trench T-7 (111.4)		X	X	X
Trench T-8 (111.5)		X	X	X
Trench T-9 (111.6)		X	X	X
Trench T-10 (111.7)		X	X	X
Trench T-11 (111.8)		X	X	X
Trench T-12		X	X	X
Trench T-13		X	X	X

[a] Ground water contamination in the UHSU occurs throughout OU2 and is non-IHSS specific.

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The 903 Drum Storage Site was used to store drums containing radioactively contaminated oils and solvents. The Mound Site was used to dispose of drums containing depleted uranium and beryllium-contaminated lathe coolant. Some drums containing tetrachloroethene were also placed in the Mound Site. In the past, waste materials were removed from both the 903 Drum Storage and the Mound Sites; the wastes were either shipped offsite for disposal or sent to Building 774 for treatment.

The trenches (T1 through T-13) were used primarily for the disposal of sanitary sewage sludge contaminated with uranium and plutonium, and flattened empty drums contaminated with uranium. Plutonium- and uranium-contaminated asphalt planking from the solar evaporation ponds may have been placed in one or more of the trenches including, but not limited to, Trenches T-4 and T-11. It is also suspected that some solvent-bearing wastes were placed in some of the trenches; however, it is not known which of the trenches received the wastes. Records indicate that approximately 125 drums containing depleted uranium chips and small amounts of lathe coolant were buried in Trench T-1. This trench is believed to have also received drums containing metal turnings, still bottoms, cemented cyanide waste, and copper alloy. Trench T-9 is reported to also contain scrap metal from production operations.

Characterization efforts conducted in support of the RFI/RI for OU2 have detected tetrachloroethene, arsenic, cadmium, mercury, uranium-233/234, -235, and -238, plutonium-239/240, and americium-241 in sufficient quantities to be assessed as COCs. The origin of several of these constituents at the 903 Pad Drum Storage Site or Trench T-2 indicates leakage from drums formerly stored at the 903 Pad Drum Storage Site and wastes disposed of in Trench T-2. Sampling efforts conducted at the Mound Site have detected volatile organic compounds (VOCs) and radionuclides. It is suspected that the presence of these constituents in subsurface soils is the result of leakage from drums that were formerly buried at the Mound Site. Elevated concentrations of VOCs, heavy metals, and radionuclides have been detected in subsurface soils at the Northeast and Southeast Trench Areas (Trenches T-3 through T-13). Only limited characterization data are available for the burial trenches. Contaminants in subsurface soils are presumed to be related to releases from buried wastes in the trenches.

2.3 Residual Surface Soil Contamination

Residual surface soil contamination is defined as surface soil contamination remaining after implementation of source removal actions and/or contamination that is present in the upper two inches of impacted soil. This definition may encompass most of the land surface in OU2 and those contamination areas that remain in OU1 following completion of OU1 source removal actions. Surface soils contaminated with low-levels of plutonium and americium in OU1 which are contiguous to OU2 are being administratively addressed under OU2 because the 903 Pad Area is believed to be the source of that portion of the surface soil plutonium and americium contamination present in OU1.

Plutonium-239/240 and americium-241 exist within surface soils throughout OU2 in sufficient quantities to be assessed as COCs. The radioactive contamination present at OU2 is believed to be the result of wind dispersion of particulate material from the 903 Pad primarily toward the south and east and extending beyond the eastern perimeter road, prior to capping (DOE, 1993b). Sampling efforts conducted to date have also indicated the presence of bis (2-ethylhexyl) phthalate throughout OU2. Although bis (2-ethylhexyl) phthalate is a common field and laboratory contaminant, it was detected at a sufficiently significant concentration to be identified as a COC. Aroclor-1254 and Aroclor-1260 have been detected in low concentrations at the Mound Area and deemed COCs; however, the source of these PCBs is unknown. Chromium (III) has been detected in localized areas at the 903 Pad Area and in an area approximately 700 feet south of the Southeast Trenches and has been deemed a COC. None of the samples analyzed as a part of the RFI/RI have indicated the presence of hexavalent chromium, even where chromium-bearing wastewater may have been disposed.

2.4 Residual Subsurface Soil Contamination

Residual subsurface soil contamination is defined as contamination remaining in subsurface soils after completion of subsurface source removal actions. The subsurface soils consist of all OU2 soils deeper than approximately two inches (EPA, 1992). Residual contamination may vary depending upon contaminant type and concentration.

Characterization efforts conducted in support of the RFI/RI for OU2 have detected tetrachloroethene, arsenic, cadmium, mercury, uranium-233/234, -235, and -238, plutonium-239/240, and americium-241 in sufficient quantities to be assessed as COCs. Subsurface soil source removal actions will be performed to reduce the quantities of these contaminants.

2.5 Upper Hydrostratigraphic Unit Ground Water Contamination

Contamination in the UHSU ground water exists throughout OU2. Source areas for UHSU ground water contamination are not clearly defined, but may originate from one or more waste pits as defined in the RFI/RI. For purposes of this technical memorandum, ground water contamination is considered to be non-IHSS specific.

Results of the Phase II RFI/RI investigation have indicated that the contamination is confined to the UHSU. Within OU2, the UHSU is comprised of variably and seasonally saturated portions of the unconsolidated surficial deposits, the Arapahoe Formation No. 1 Sandstone that is in hydraulic connection with the saturated surficial materials, and weathered claystones of the Arapahoe and/or Laramie Formations.

Ground water flow within the UHSU is complex because of areal variation in ground water flow directions, and interactions between saturated thickness. Ground water flow within the UHSU is strongly influenced by the bedrock paleotopography and by the geometry and hydraulic characteristics of the various soils and bedrock lithology comprising the UHSU.

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The Arapahoe Formation No. 1 Sandstone has been determined to be capable of yielding water supply volume adequate for domestic use (DOE, 1993). Since the source of surface water seeps within OU2 is believed to be ground water, the seeps are being addressed as part of the ground water remediation effort.

Characterization efforts conducted in support of the RFI/RI indicate the presence of organics and radionuclides in sufficient quantities to be assessed as COCs within the UHSU of the 903 Pad Area, the Mound Area, and East Trenches Area. Contaminants detected include 1,1-dichloroethene, carbon tetrachloride, chloroform, methylene chloride, tetrachloroethene, trichloroethene, americium-241, and plutonium-239/240.

3.0 CHEMICALS OF CONCERN

The COCs for which C/RAOs were developed for OU2 originate from the human health risk assessment (DOE, 1994a). The Environmental Evaluation Risk Assessment specific to OU2 was rescoped in favor of ecological studies which will encompass the Woman Creek and Walnut Creek watersheds, which are currently being prepared.

3.1 Human Health Chemicals of Concern

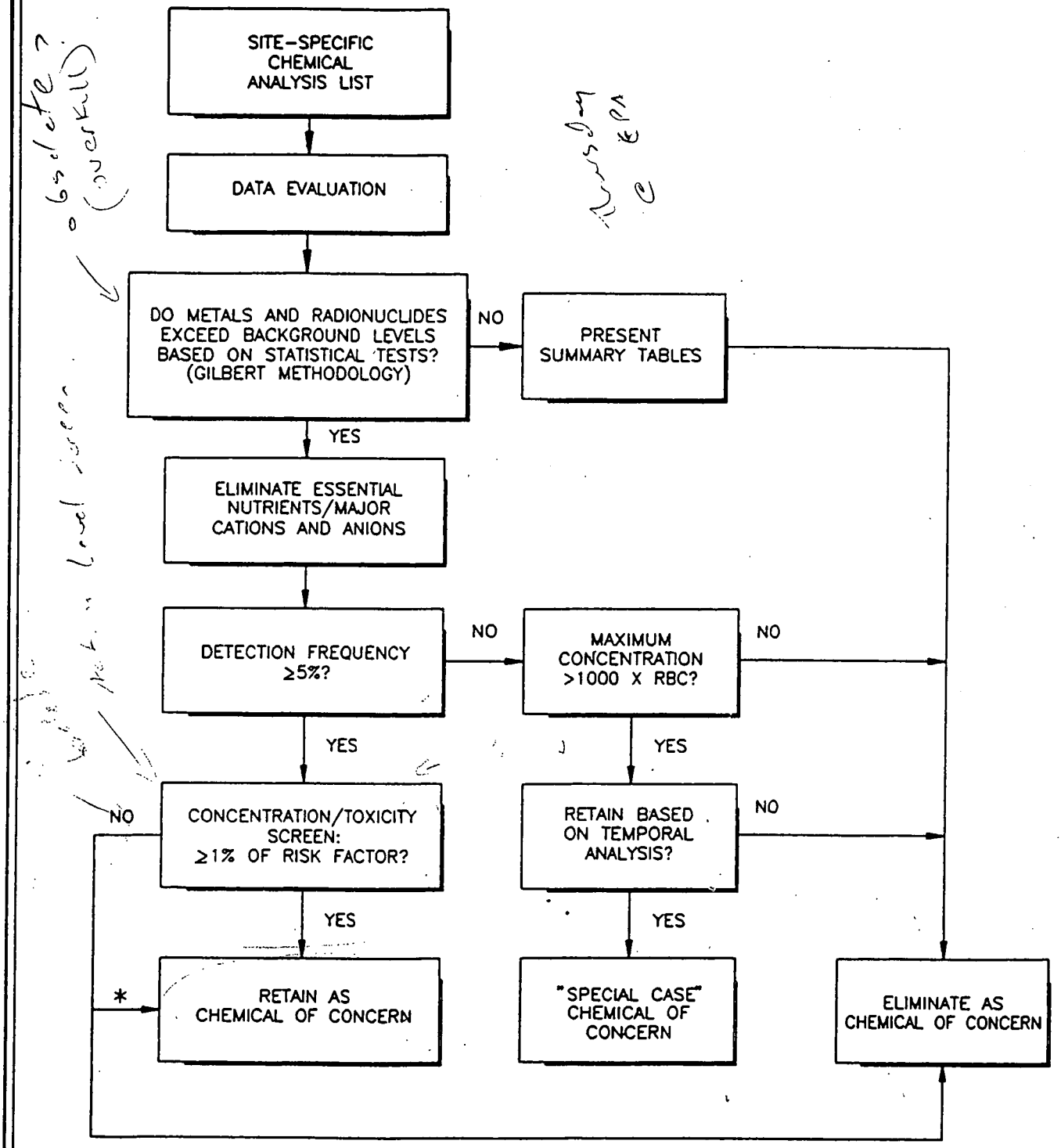
Technical Memorandum No. 9 for OU2 (DOE, 1994a) presents a method for identifying COCs and contains a list of COCs that will be included in the human health risk assessment for soil and ground water contaminants. The process used for selecting human health COCs is presented in Figure 3-1. Selection of the COCs was based on guidance presented in *Risk Assessment for Superfund, Volume I, Human Health Evaluation Manual, Part A* (EPA, 1989). The selection process consisted of five steps:

- Statistical comparison of OU2 data to background concentrations (metals and radionuclides);
- Elimination of essential nutrients and anions;
- Further evaluation of contaminants detected at a frequency greater than 5 percent;
- Screening for concentration/toxicity of contaminants using maximum detected concentrations and EPA-established toxicity factors; and
- Screening of special-case contaminants (including an evaluation of infrequently detected compounds and a spatial and temporal evaluation of infrequently detected but potentially hazardous compounds).

For example, inorganic compounds whose concentrations were within background range or that were minor constituents (e.g., rarely detected and/or of low toxicity) were excluded as COCs. Organic compounds that would not significantly contribute to overall risk also were excluded. Table 3-1 contains a summary of the organic and inorganic COCs and affected media identified during the human health risk assessment.

3.2 Environmental Chemicals of Concern

The Environmental Evaluations in progress will address the Woman Creek and Walnut Creek watersheds. Determination of whether or not environmental receptors are at risk from exposure to contaminants at OU2 has not yet been finalized. In the absence of quantitative exposure pathways to environmental receptors, it is assumed that the remediation targets established for the protection of human health will also be protective of the environment and will



* PROFESSIONAL JUDGEMENT
RBC RISK-BASED CONCENTRATION

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Figure 3-1

Operable Unit No.2
Technical Memorandum No.1
Corrective/Remedial Action Objectives
General Methodology for Selecting Chemicals of Concern for OU2 Human Health Risk Assessment

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TABLE 3-1
CHEMICALS OF CONCERN
(HUMAN HEALTH)

Chemical of Concern [a/]	Surface Soil	Subsurface Soil	UHSU Ground Water
Arsenic	---	X	---
Cadmium	---	X	---
Chromium (III)	X	---	---
Mercury	---	X	---
Aroclor-1254	X	---	---
Aroclor-1260	X	---	---
Bis(2-ethylhexyl)phthalate	X	---	---
1,1-Dichloroethene	---	---	X
Carbon Tetrachloride	---	---	X
Chloroform	---	---	X
Methylene Chloride	---	---	X
Tetrachloroethene	---	X	X
Trichloroethene	---	---	X
Vinyl Chloride [b/]	---	---	X
Americium-241	X	X	X
Plutonium-239/240	X	X	X
Uranium-233/234	---	X	---
Uranium-235	---	X	---
Uranium-238	---	X	---

NOTES

[a/] Chemicals of concern are based on human health risk assessment presented as Technical Memorandum No. 9 for OU2 (DOE, 1994a).

[b/] Identified as special-case chemical of concern in Technical Memorandum No. 9 for OU2 (DOE, 1994a).

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form the basis for identifying and evaluating remedial alternatives for each of the five remediation areas. Should completion of the Environmental Evaluation indicate that more stringent final PRGs need to be established to ensure protection of the environment, the CMS/FS report will be revised accordingly.

4.0 DEVELOPMENT OF CORRECTIVE/REMEDIAL ACTION OBJECTIVES

The IAG requires that an appropriate range of C/RAOs be established to screen and evaluate corrective/remedial alternatives. The C/RAOs are, at a minimum, to be developed for the protection of human health and the environment. These objectives shall specify the contaminants and media of interest, exposure pathways, and acceptable contamination levels or ranges of levels for each exposure route.

The corrective action objectives have been identified so that applicable Resource Conservation and Recovery Act (RCRA) closure and corrective action requirements are properly considered during development of the CMS/FS. Closure of RCRA regulated units will be conducted in accordance with the *Final RCRA Corrective Action Plan* (EPA, 1994). Limited regulatory guidance exists regarding development of corrective action objectives under RCRA. For the purpose of remediating OU2, corrective action objectives have been established to ensure that closure and waste management constraints of RCRA are part of the remedial alternative evaluation process. For those wastes determined to be hazardous, proper management will be incorporated into implementation of the selected remedial alternative.

The remedial action objectives have been identified so that applicable Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup requirements are also properly considered. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) discusses development of remedial action objectives and PRGs. Remedial action objectives are contaminant- and medium-specific goals for protecting human health and the environment. In developing appropriate remedial action objectives, the EPA guidance document states that "objectives should be as specific as possible, but not so specific that the range of alternatives that can be developed is unduly limited." The guidance also specifies that in order to quantify remedial action objectives, PRGs are to be developed that identify an acceptable contaminant level or range of levels for each exposure route of concern.

The combined consideration of RCRA corrective and CERCLA remedial action objectives will integrate the implementation of these two environmental protection programs into the remediation efforts at OU2. The media-specific C/RAOs that have been identified for OU2 are listed below.

- Remediate contaminated soils to non-zero chemical-specific ARARs/TBCs, as appropriate;
- In the absence of applicable ARARs/TBCs, prevent exposure to contaminated surface soils that would result in a total excess cancer risk greater than 10^{-4} to 10^{-6} or a hazard index of greater than one for noncarcinogens;
- In the absence of applicable ARARs/TBCs, prevent exposure to contaminated subsurface soils that would result in a total excess cancer risk greater than 10^{-4} to 10^{-6} or a hazard index greater than 1 for noncarcinogens;

Remediate to Risk Based Level

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- Remediate the ground water aquifer to non-zero chemical-specific ARARs/TBCs, as appropriate; and

- In the absence of ARARs, prevent exposure to contaminated ground water that would result in a total excess cancer risk of greater than 10^{-4} to 10^{-6} or a hazard index greater than one for noncarcinogens.

The OU2 C/RAOs were developed using appropriate regulatory guidelines (EPA, 1988) and regulations in the NCP, and by examining relevant COCs and site-specific exposure pathways discussed in Section 5.0 of this technical memorandum. It is assumed that by meeting the criteria established for the protection of human health, the environment is adequately protected. Should the BRA or Environmental Evaluation for OU2 identify additional COCs or exposure pathways not addressed in this technical memorandum, the C/RAOs will be revised accordingly and incorporated as part of the CMS/FS.

Remediate Subsurf Soils to meet GW objectives, if technically feasible

~~Subsurf Soils not protective to GW.~~

what about GW Receptor.

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5.0 DEVELOPMENT OF REMEDIATION TARGETS

As required by CERCLA Section 121(d), remedial actions shall attain a degree of cleanup of hazardous substances released into the environment and control future releases, at a minimum which protects human health and the environment. The NCP and EPA's RI/FS guidance documents require the establishment of PRGs that specify the degree of cleanup the remedial action must achieve to protect human health and the environment. The PRGs are environmental media- and contaminant-specific values developed on the basis of chemical-specific ARARs, site-specific risk-related factors, and other readily available information.

Although the incomplete RFI/RI portions could influence selection of final remediation goals for OU2, preliminary remediation targets have been established to allow the CMS/FS to proceed with development of potential remedial alternatives. The remediation targets may need modification as the CMS/FS progresses. Final remediation goals that are mutually agreeable to the participating agencies (i.e., DOE, EPA, and Colorado Department of Public Health and Environment [CDPHE]) will be identified in the ROD for OU2. A brief description of the information sources and their incorporation into the selection of the remediation targets is provided below.

Chemical-Specific ARARs

The DOE is responsible for identifying those promulgated standards, requirements, criteria, or limitations (i.e., ARARs) to be met during implementation of the selected remedy. *Applicable* requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental, or State environmental or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. *Relevant and Appropriate* requirements are those cleanup standards, standards of control, and other substantive requirements; criteria, or limitations promulgated under Federal environmental, or State environmental or facility citing laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only State standards that are promulgated and identified in a timely manner by the State, and are more stringent than Federal requirements qualify as ARARs. For purposes of identification and notification of State standards, the term "promulgated" means that the standards are of general applicability and are legally enforceable.

In addition to ARARs, other non-promulgated advisories, criteria, or guidance documents that are to-be-considered (TBCs) to supplement an ARAR provision for a particular release may be identified. TBCs are not legally binding, and do not have the status of potential ARARs. However, TBCs can be used, when suitable, to determine the level of cleanup required to protect human health and the environment.

This technical memorandum only addresses the identification of potential chemical-specific ARARs/TBCs for the purpose of developing remediation targets for the OU2 COCs. Action- and location-specific ARARs will be addressed during the screening of remedial technologies for OU2. Chemical-specific ARARs are health- or risk-based numerical values that establish the acceptable amount or concentration of a compound that may be found in or discharged to the ambient environment (e.g., air emissions or wastewater discharges). Chemical-specific ARARs may also specify methodologies which, when applied to site-specific conditions, result in the establishment of numerical values that are protective of human health and/or the environment. The chemical-specific ARARs/TBCs presented in this technical memorandum are consistent with the ARAR identification process contained in the *Draft Master List of Potential Federal and State ARARs for the Rocky Flats Environmental Technology Site* (DOE, 1994c)

Preliminary Risk-Based Remediation Goals

When chemical-specific ARARs are not available or are not considered sufficiently protective because of the presence of multiple contaminants or multiple exposure pathways, calculated risk-based values can be used to establish contaminant levels that are considered to be protective of human health. As previously discussed, the risk characterization components have not been finalized for OU2. Potential exposure routes and receptors to be used in the BRA for OU2 are currently being refined. In an effort to proceed with the CMS/FS for OU2, programmatic exposure pathways were developed and used in calculating preliminary risk-based remediation goals. Table 5-1 summarizes the programmatic exposure routes and receptors. These programmatic exposure pathways include major exposure routes that will most likely be addressed in the BRA for OU2. Should the BRA identify additional exposure pathways not programmatically addressed, the required changes will be incorporated during the development of the CMS/FS. The methodology and equations used to calculate the preliminary risk-based remediation goals are presented in *Programmatic Risk-Based Preliminary Remediation Goals* (DOE, 1994) and the *Programmatic Risk-Based Preliminary Remediation Goals for the Sand and Gravel Mining Land Use Exposure Scenario - Draft* (DOE, 1994d).

Two exposure levels of each COC were used to calculate risk-based PRGs for consideration in selecting the OU2 remediation targets: the reasonable maximum exposure (RME) and the central tendency (CT). The RME and CT represent exposure to different concentrations of a chemical (PRG). The RME exposure level is the highest exposure that is reasonably expected to occur at a site and in practice is estimated by combining the 90 - 95th percentile values for some but not all exposure parameters. The PRG values calculated using RME levels represent the smallest contaminant concentration that the receptor can be exposed to which may result in a risk level that exceeds 10^{-6} or a hazard index greater than 1. The RME values used to calculate the PRGs originate from the *Programmatic Risk-Based Preliminary Remediation Goals* document (DOE, 1994). The CT represents the arithmetic mean exposure level and uses average for some, but not necessarily all exposure factors. The PRG values calculated using CT levels may provide a more realistic (e.g. less conservative) contaminant

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TABLE 5-1

PROGRAMMATIC EXPOSURE PATHWAYS

Environmental Media	Exposure Scenario			
	Residential	Commercial\Industrial		Ecological Researcher
Surface Soil	Direct Ingestion of Soils [a] Inhalation of Particulates [b] External Exposure to Radiation	Office Worker Scenario Direct Ingestion of Soils [a] Inhalation of Particulates [b] External Exposure to Radiation		Direct Ingestion of Soils [a] Inhalation of Particulates [b] External Exposure to Radiation
Subsurface Soil	Not Applicable	Gravel Miner Worker Scenario Direct Ingestion of Soils [a] Inhalation of Particulates [b] External Exposure to Radiation Inhalation of Volatiles [c]	Construction Worker Scenario Direct Ingestion of Soils [a] Inhalation of Particulates [b] External Exposure to Radiation Inhalation of Volatiles [c]	Not Applicable
Ground Water	Direct Ingestion of Ground Water [a] Inhalation During Domestic Use [c]	Not Applicable		Not Applicable

NOTES:

[a] Includes assessment of organics and inorganics (including radionuclides).

[b] Includes assessment of non-volatile organics and inorganics (including radionuclides).

[c] Includes assessment of volatile organics.

concentration which is protective of human health based on an average receptor. The intent of providing both RME and CT risk-based PRGs is to determine the sensitivity of contaminant concentrations with respect to risk. Appendix A contains a summary of the RME and CT exposure factors used to calculate PRGs for this technical memorandum. The exposure factors used to calculate both RME and CT exposure levels for the sand and gravel mining exposure scenario and the remainder of the CT exposure levels are consistent with those presented in *Technical Memorandum No. 5, Exposure Scenarios, Human Health Risk Assessment, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2* (DOE, 1994b).

The RME and CT PRGs for carcinogens were calculated by setting the carcinogenic target risk level at 10^{-6}. A target risk level of 10^{-6} means an individual has a one-in-one-million probability of developing cancer over a lifetime as a result of an assumed exposure to a specific contaminant concentration. This risk is additional to the probability of an individual developing cancer from other factors such as those associated with heredity or lifestyle. Similarly, the RME and CT PRGs for toxicants (noncarcinogens) were calculated by setting the hazard quotient at one for each contaminant. A hazard quotient is the ratio of a single substance exposure level of a chemical contaminant over a specified period to the reference dose for the chemical. The reference dose represents an estimate of an exposure level for the human population, including sensitive subpopulations, that is likely to be without appreciable deleterious effects during a lifetime. Since the plutonium-239 and -240, and uranium-233 and -234 isotopes are reported as a single analyte (i.e., plutonium-239/240 and uranium-233/234, respectively), the reported PRG value is the lowest PRG value calculated for the respective isotopes. Using the lowest value is the most conservative approach in establishing remediation targets for these radionuclides. Based upon the stream averages of plutonium isotopes historically processed for weapons reserve, over 99.5% of the total plutonium from productions operations can be measured as plutonium-239/240. Contaminant-specific toxicity information used to calculate both the RME and CT preliminary risk-based remediation goals for the OU2 COCs are summarized in Appendix B.

Other Readily Available Information

Other information such as background concentrations, minimum analytical detection limits, and cleanup standards that have been determined to be protective at other remediation sites may also be considered when establishing final site-specific PRGs. The consideration of these other factors were used to verify that chemical-specific ARARs and/or calculated risk-based concentrations are achievable and reasonable. The background concentration information was obtained from the *Final Background Geochemical Characterization Report* (DOE, 1993c) and background surface soil samples collected in the Rock Creek Area during the 1991 OU1 Phase III investigation and the 1993 OU2 Phase II investigation. Cleanup standards that have been adopted at other remediation sites were derived from reviewing available RODs for CERCLA remedial action undertaken at sites within Colorado.

5.1 Surface Soils

Table 5-2 presents the background concentrations, minimum analytical detection limits, potential chemical-specific ARARs/TBCs, risk-based PRGs, maximum detected concentrations of each contaminant, and cleanup standards established at other Colorado remediation sites that were considered in setting remediation targets for OU2 surface soil COCs. The source and methods used to calculate these potential cleanup standards are addressed under the categories of chemical-specific ARARs/TBCs and risk-based criteria in the following subsections.

5.1.1 Background Concentrations

The background concentrations for metals and radionuclides in surface soils were obtained from background surface soil samples collected in the Rock Creek Area during the 1991 OU1 Phase III investigation and the 1993 OU2 Phase II investigation. Background sampling was not conducted for organic compounds; therefore, a background concentration of zero was assigned to bis (2-ethylhexyl) phthalate, Aroclor-1254, and Aroclor-1260.

5.1.2 Potential Chemical-Specific ARARs/TBCs

Chemical-specific ARARs/TBCs for soil, which establish protective levels based on risks to human health and/or the environment, only exist for PCBs and radionuclides and not other OU2 surface soil COCs. Cleanup standards for soils contaminated with PCBs are regulated under the Toxic Substances Control Act (TSCA). The TSCA requirements for cleaning up PCB spills are considered TBCs. Although PCB spills that occurred prior to May 4, 1987 are excluded from 40 CFR 761, Subpart G (EPA's PCB Spill Cleanup Policy), DOE believes that the cleanup targets in the policy are protective of human health and the environment at OU2. The Policy establishes a soil cleanup target of 25 ppm PCBs by weight in restricted areas. The DOE believes that OU2 meets the definition of a restricted area, as it is located within an industrial site where access is limited and it is separated by over 0.1 kilometer from any residential/commercial area as defined in 40 CFR Section 761.123.

The Atomic Energy Act (AEA) grants DOE authority over AEA-regulated radionuclides. Pursuant to this authority, the DOE has established radiation protection standards for offsite members of the public under *Radiation Protection of the Public and the Environment*, DOE Order 5400.5 (DOE, 1990). To ensure that the offsite radiation dose is maintained at acceptable levels, the DOE has developed an annual radiation dose limit of 100 millirem effective dose equivalent to members of the public. The provisions of DOE Order 5400.5 are currently in the process of being promulgated as 10 CFR 834. The annual radiation dose limit of 100 millirem effective dose equivalent is considered a TBC until promulgation of 10 CFR 834, at which time the annual radiation dose limit will be identified as an ARAR.

The TBC values based on the annual radiation dose limit of 100 millirem effective dose equivalent were calculated using the exposure scenarios and exposure pathways outlined in the *Programmatic Risk-Based Preliminary Remediation Goals* (DOE, 1994). The RME parameters

were used to calculate the TBC values. The TBC values calculated using RME levels represent the radionuclide concentration that the receptor can be exposed to which may result in an annual effective dose equivalent of 100 millirem. The fact that multiple radionuclides contribute to the radiation dose for a specific exposure scenario will be addressed before final remediation goals are established.

Nuclear Regulatory Commission (NRC) standards for radionuclides were not considered to be potential ARARs. The standards are not applicable to the RFETS because the DOE is exempt from NRC regulations. The NRC standards were also determined not to be appropriate since the DOE is required to and has established radiation protection standards for offsite members of the public pursuant to DOE Order 5400.5 (which is currently in the process of being promulgated as 10 CFR 834).

5.1.3 Preliminary Risk-Based Remediation Goals

The potential future receptors considered in calculating the PRGs for surface soil include residents, office workers, and ecological researchers. The programmatic exposure pathways considered for each of the hypothetical future receptors include direct ingestion of soils, inhalation of particulates, and external exposure to radiation.

5.1.4 Cleanup Standards at Other Colorado Sites

A review of RODs that have been issued for other CERCLA remediation sites located in the State of Colorado was conducted to determine what values have been previously used as soil cleanup standards. An electronic search of EPA's RODS database was performed to obtain a list of Colorado sites where soil remediation was specified. Two RODs were identified that contained at least one or more of the COCs: the Martin Marietta, Denver Aerospace Site, and Sand Creek Industrial Site, (OU5).

The ROD for the Martin Marietta, Denver Aerospace Site contained action levels for PCBs, bis (2-ethylhexyl) phthalate, and chromium (total) to define when treatment was required to protect the ground water resources. The action and treatment levels for PCBs were based upon TSCA. The action level for total chromium was based upon background concentrations. The treatment standard was for total chromium (both chromium III and VI) and was based upon the RCRA toxicity characteristics (TC) determination established in 40 CFR 261. There was no action level for bis (2-ethylhexyl) phthalate, and the treatment standard was based upon the federal and state hazardous waste regulations.

The ROD for the Sand Creek Industrial Site (OU5), specified an action level for chromium (total) which was similar to the action level specified in the Martin Marietta ROD. The action level was based on a 1E-5 risk level.

It should also be noted that there was no distinction in the RODs for cleanup standards for surface and subsurface soils. As such, comparing the cleanup values from the RODs for soils contained in Table 5-2 against the preliminary risk-based remediation goals for surface soils may not be appropriate.

5.1.5 Selected Remediation Targets for Surface Soils

The NCP states that preliminary remediation goals are to be developed based on readily available information, such as chemical-specific ARARs. For known or suspected carcinogens, the 10^{-6} is to be used as the point of departure for determining remediation goals for remedial alternatives when ARARs are not available or are not sufficiently protective of human health and the environment [40 CFR 300.430 (e)(2)((i)(A)(2)]. Selected remediation targets for the OU2 surface soils were based on ARARs/TBCs when available, and RME PRGs for an office worker exposure scenario.

The cleanup criteria established in 40 CFR 761 for PCBs (e.g., 25 ppm) was selected as the remediation target for PCB contaminated soils because the standard has been determined to be a TBC (see Section 5.1.2) is a widely accepted regulatory standard, and the NCP requires, in most cases, that ARARs or other reliable information be preferentially selected over risk-based PRGs as final remediation goals.

For bis (2-ethylhexyl) phthalate, the commercial/industrial (office worker) RME PRG was selected as the remediation target. The RME PRGs are considered to be sufficiently conservative for the purpose of proceeding with the identification and development of remedial alternatives for the following reasons:

- Since bis (2-ethylhexyl) phthalate exhibits both carcinogenic and noncarcinogenic properties, the lowest of the office worker RME values were selected as the remediation target;

- The NCP requires sites to be remediated so that the lifetime risk to an individual is between 10^{-4} to 10^{-6} for known or suspected carcinogens. As required, the 10^{-6} risk level is being used as the point of departure for determination of the RME PRGs;

- Decisions regarding the future land use for RFETS have not been finalized; however, the DOE Rocky Flats Field Office Future Site Use Working Group is expected to recommend that onsite residential use should be eliminated from the future land use plan (meeting minutes, 12/8/94). Therefore, risk-based PRGs for the most conservative non-residential exposure scenario (i.e. commercial/industrial scenario) were utilized;

- The EPAs Risk Assessment Council states that all risk assessments shall evaluate both the RME and CT exposure levels. The EPA guidance states that for

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decision-making purposes in the Superfund Program, the RME exposure level should be used to estimate risk (EPA, 1992a). The EPA recommends presenting the CT exposure level for comparative purposes during the risk assessment process. Consequently, the more conservative RME PRGs have been used to establish remediation targets and will also be used in the subsequent screening of remedial alternatives. During the detailed analysis of remedial action alternatives, both the RME and CT PRGs will be considered. Including the CT PRGs provides a range of cleanup values that allows greater flexibility in assessing potential remediation technologies.

It should be noted that the commercial/industrial PRGs for chromium III are greater than 10^6 parts per million. Consequently, the remediation target presented for chromium III is set at 10^6 parts per million, since no practical limit in soil exists.

The acceptable soil limit based on an annual radiation dose limit of 100 millirem from DOE Order 5400.5 was selected as the remediation target for radionuclide-contaminated soils because the standard has been determined to be a TBC (see Section 5.1.2) and the NCP requires, in most cases that ARARs or other reliable information be preferentially selected over risk-based PRGs as final remediation goals. The commercial/industrial exposure scenario was used as the based for the radionuclide TBC calculations for the reasons indicated in the above discussion of risk-based PRGs.

The cleanup standards established at other Colorado NPL sites were considered only to verify that the selected remediation target is consistent with previously approved RODs. With the exception of chromium III and bis (2-ethylhexyl) phthalate, the selected remediation targets appear to be consistent with ROD cleanup levels. This inconsistency is due to the action levels being based upon promulgated hazardous waste standards versus calculated risk-based values. The cleanup standard for PCB is representative of cleanup standards shown in RODs that have been reviewed for the State of Colorado.

5.2 Subsurface Soils

Table 5-3 presents the background concentrations, minimum analytical detection limits, potential chemical-specific ARARs/TBCs, risk-based PRGs, maximum detected concentrations of each contaminant, and cleanup standards established at other Colorado remediation sites that were considered in setting remediation targets for the OU2 subsurface soil COCs. The source and the methods used to calculate these potential cleanup standards are addressed in the following subsections.

5.2.1 Background Concentrations

The background concentrations for metals and radionuclides in subsurface soils were obtained from the *Final Background Geochemical Characterization Report* (DOE, 1993c). Background sampling was not conducted for organic compounds (i.e., tetrachloroethene); therefore, a background concentration of zero was assigned to tetrachloroethene.

5.2.2 Potential Chemical-Specific ARARs/TBCs

No federal or state chemical-specific ARARs/TBCs were identified as potential PRGs for the OU2 subsurface soil COCs, except for radionuclides.

The Atomic Energy Act (AEA) grants DOE authority over AEA-regulated radionuclides. Pursuant to this authority, the DOE has established radiation protection standards for offsite members of the public under *Radiation Protection of the Public and the Environment*, DOE Order 5400.5 (DOE, 1990). To ensure that the offsite radiation dose is maintained at acceptable levels, the DOE has developed an annual radiation dose limit of 100 millirem effective dose equivalent to members of the public. The provisions of DOE Order 5400.5 are currently in the process of being promulgated as 10 CFR 834. The annual radiation dose limit of 100 millirem effective dose equivalent is considered a TBC until promulgation of 10 CFR 834, at which time the annual radiation dose limit will be identified as an ARAR.

The TBC values based on the annual radiation dose limit of 100 millirem effective dose equivalent were calculated using the exposure scenarios and exposure pathways outlined in the Programmatic Risk-Based Preliminary Remediation Goals (DOE, 1994). The RME parameters were used to calculate the TBC values. The TBC values calculated using RME levels represent the radionuclide concentration that the receptor can be exposed to which may result in an annual effective dose equivalent of 100 millirem. The fact that multiple radionuclides contribute to the radiation dose for a specific exposure scenario will be addressed before final remediation goals are established.

Nuclear Regulatory Commission (NRC) standards for radionuclides were not considered to be potential ARARs. The standards are not applicable to the RFETS because the DOE is exempt from NRC regulations. The NRC standards were also determined not to be appropriate since the DOE is required to and has established radiation protection standards for offsite members of the public pursuant to DOE Order 5400.5 (which is currently in the process of being promulgated as 10 CFR 834).

5.2.3 Preliminary Risk-Based Remediation Goals

Potential future receptors considered in calculating the PRGs for subsurface soil included the commercial/industrial scenarios for both gravel miners and construction workers. The calculations assume that the primary risk is due to direct ingestion of soils, inhalation of particulates, inhalation of VOCs, and external exposure to radiation. The PRGs for radionuclides were calculated with daughter products, where applicable.

5.2.4 Cleanup Standards at Other Colorado Sites

Because of the number of contaminants present in the subsurface at OU2, no single ROD was identified that contained the same contaminants; however, the following 6 RODs were identified that contained at least one or more of the COCs:

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- Broderick Wood Products, Co. [EPA/ROD/R08-92/057];
- Denver Radium, Co. (OU9) [EPA/ROD/R08-92/062];
- Martin Marietta, Denver Aerospace, Co.[EPA/ROD/R08-90/035];
- Sand Creek Industrial, Co. (OU1) [EPA/ROD/R08-89/024];
- Sand Creek Industrial, Co. (OU5) [EPA/ROD/R08-93/04]; and
- Woodbury Chemical, Co. [EPA/ROD/R08-89/026].

Action levels for arsenic were found in RODs for the Broderick Wood Products, Denver Radium, Sand Creek Industrial (OU5), and Woodbury Chemical Company Sites. Action levels that were reported ranged from 5 - 79 ppm and were primarily risk-based values. Action levels for cadmium and mercury were found in the Martin Marietta, Denver Aerospace Site ROD and were based on background. Treatment standards for cadmium and mercury in the Martin Marietta ROD were based on the RCRA TC determination. The ROD for the Broderick Wood Products did not specify an action level, but did specify a treatment level for cadmium of 1 mg/kg. Finally, action levels for tetrachloroethene were found in the ROD for the Sand Creek Industrial Site, OU1. The action level was risk-based using a ground water pathway and a 1E-6 risk level.

It should be noted that there was no distinction in the RODs for cleanup standards for surface and subsurface soils. It is unclear whether the ROD standards were established for exposure to contaminants via a surface or subsurface soil exposure pathway, or were established to protect ground water resources. If the ROD cleanup standards are indeed for subsurface soils, it is not known which exposure scenario was used as the basis to calculate the limits. As such, comparing the cleanup values from the RODs for soils contained in Table 5-3 against the risk-based preliminary remediation goals for subsurface soil may not be appropriate.

5.2.5 Selected Remediation Targets for Subsurface Soils

Due to the lack of ARAR/TBC standards for the remediation of non-radionuclide contaminants in subsurface soils, the RME PRGs for a construction worker scenario were selected as remediation targets. The RME PRGs for the gravel miner were not selected because the feasibility of mining OU2 for commercial purposes is not considered viable, but is currently being evaluated. Should gravel mining be identified as a viable future land-use option for OU2, the PRGs and remedial alternatives will be revised accordingly. As discussed in Section 5.1.5, the RME PRGs are considered to be sufficiently conservative for the purpose of proceeding with the identification and development of remedial alternatives.

The acceptable soil limit based on an annual radiation dose limit of 100 millirem from DOE Order 5400.5 was selected as the remediation target for radionuclide-contaminated soils because the standard has been determined to be a TBC (see Section 5.1.2) and the NCP requires, in most cases, that ARARs or other reliable information be preferentially selected over risk-based PRGs as final remediation goals. The commercial/industrial exposure scenario was used as the basis for the radionuclide TBC calculations for the reasons indicated in the discussion of risk-based PRGs above.

The cleanup standards established at other Colorado NPL sites were considered only to verify that the selected remediation target is consistent with previously approved RODs. Although several of the selected remediation targets exceeded previously established cleanup standards for RODs, a direct comparison of the values may not be appropriate since there was no distinction in the RODs between surface and subsurface soil for the RODs reviewed.

5.3 Ground Water

Table 5-4 presents the background concentrations, minimum analytical detection limits, potential chemical-specific ARARs/TBCs, risk-based PRGs, maximum detected concentrations of each contaminant, and cleanup standards established at other Colorado remediation sites that were considered in setting remediation targets for the OU2 ground water COCs. The source and the methods used to calculate these potential cleanup standards are addressed in the subsections that follow.

5.3.1 Background Concentrations

The background concentrations for radionuclides in ground water were obtained from the *Final Background Geochemical Characterization Report* (DOE, 1993c). Background sampling was not conducted for VOCs; therefore, a background concentration of zero was assigned to the VOCs listed in Table 5-4.

5.3.2 Potential Chemical-Specific ARARs/TBCs

The Federal and State chemical-specific ARARs/TBCs that were considered for selecting the remediation targets for OU2 are identified in Table 5-4 and include:

- Federal Water Quality Criteria (eg., Gold Book) issued by EPA pursuant to Section 303 of the Clean Water Act;
- Federal MCLs and non-zero MCLGs adopted under the Safe Drinking Water Act, (see 40 CFR 141 and 142);
- State of Colorado Primary Drinking Water Regulations (see 5 CCR 1003-1);

- State of Colorado Statewide ground water quality standards (see 5 CCR 1002-8, Sections 3.11);

- State of Colorado ground water protection standards for hazardous waste facilities (see 6 CCR 1007-3, 264.94); and

- DOE Order 5400.5 (DOE, 1990).

EPA's fact sheet entitled *ARARs Questions and Answers: Compliance With Federal Water Quality Criteria* (EPA, 1990) was followed to determine the hierarchy of Federal requirements that are identified as potential ARARs/TBCs. The application of these standards to the remediation of ground waters beneath OU2 is discussed in the following paragraphs.

Although water quality standards are typically not applicable to CERCLA response actions, the NCP states that water quality criteria established under Section 303 or 304 of the Clean Water Act qualify as PRGs only when they are determined to be relevant and appropriate to the circumstance of the release. [See 40 CFR 300.430(e)(2)(i)(E)]. The NCP also states that MCLs and non-zero MCLGs are to be attained by remedial actions for ground or surface waters that are current or potential sources of drinking water. [See 40 CFR 300.430(e)(2)(i)(B)]. Federal MCLs and non-zero MCLGs were determined to be potentially relevant and appropriate, except standards for AEA regulated radionuclides. Since Colorado is authorized to implement the Federal Safe Drinking Water Act program, State drinking water regulations could be potential ARARs. In order for a State standard to be designated as an ARAR, the State requirement is to be more stringent than the corresponding Federal standard. For completeness, both Federal and State drinking water standards have been identified in Table 5-4.

The Colorado Water Quality Control Commission (WQCC) has promulgated ground water standards for all source ground water, unclassified and classified; ground water that has been classified for a specific existing or potential use; and site-specific standards. [See 5 CCR 1002-8, Sections 3.11 and 3.12]. Despite questions regarding enforceability, the Statewide standards for ground water that has not been classified for a specific existing or potential use will be considered potential ARARs, except standards for AEA-regulated radionuclides.

The Colorado WQCC has site specifically classified the Quaternary and Rocky Flats aquifers beneath the RFETS as domestic use quality, agricultural use quality, and surface water protection. The Colorado WQCC has also designated site-specific ground water standards to RFETS. [See 5 CCR 1002-8, Section 3.12.7]. However, in order for the standards associated with the site specific use classification and the site-specific standards to be identified as ARARs they must be of "general applicability" and "enforceable". [See 40 CFR 300.400(g)(4)]. The RFETS site-specific ground water use classifications, and their associated standards, and the RFETS site-specific standards [5 CCR 1002-8, Section 3.12.7] are not considered ARARs because those use classifications, and their associated standards, and the site-specific standards have not been generally applied to other remedial sites throughout the State. The RFETS is the only industrial site in Colorado that has the State ground water use classifications of domestic

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use quality, agricultural use quality, and surface water protection imposed upon it. The RFETS is the only industrial site in Colorado to have site-specific standards [5 CCR 1002-8, Section 3.12.0] for parameters that have probably been used at other industrial sites in Colorado.

The hazardous waste facility ground water protection standards are not considered to be applicable since none of the OU2 IHSSs are designated hazardous waste management units. Since other, more relevant, ground water protection ARARs have been identified for drinking water supplies (i.e., MCLs), the hazardous waste facility ground water protection standards were not considered to be relevant and appropriate to OU2.

With respect to radionuclides, the AEA grants DOE authority over AEA regulated radionuclides. Pursuant to this authority, DOE has established radiation protection standards for offsite members of the public under DOE Order 5400.5 (DOE, 1990). To ensure that the offsite radiation dose is maintained below established limits, DOE has developed Derived Concentration Goals (DCGs) for exposures via the ground water pathway based on an annual dose limit of 100 millirem effective dose equivalent to offsite members of the public. The fact that multiple radionuclides contribute to the radiation dose for a specific exposure scenario will be addressed before final remediation goals are established. These DCGs will be considered in selecting protective remediation targets for the OU2 ground water. The provisions of DOE Order 5400.5 are currently in the process of being promulgated as 10 CFR 834. The DCGs are considered TBCs until promulgation of 10 CFR 834, at which time the DOE ground water protection requirements will be identified as ARARs.

Ground water standards for radionuclides developed by the NRC were not considered to be ARARs. These standards are not applicable to the RFETS because the DOE is exempt from NRC regulation. The NRC standards were also determined not to be appropriate since DOE is required to and has established radiation protection standards for offsite members of the public pursuant to DOE Order 5400.5 (which is currently in the process of being promulgated as 10 CFR 834).

5.3.3 Preliminary Risk-Based Remediation Goals

The PRGs for ground water COCs were determined using standard exposure assumptions for residential use of ground water (EPA, 1991). The calculation of the risk-based goals using the residential land use scenario assumes that the primary risk is from direct ingestion of ground water contaminated with organics, inorganics, and radionuclides, and inhalation of VOCs from household ground water use. Although the DOE Rocky Flats Field Office Future Site Use Working Group is expected to recommend that onsite residential use should be eliminated from the future land use plan (see Section 5.1.5), the risk-based PRGs for the residential ground water use scenario are presented for consistency with the programmatic exposure pathways.

5.3.4 Cleanup Standards at Other Colorado Sites

The following eight RODs were used as the basis for the range of cleanup standards presented in Table 5-4:

- Chemical Sales (OU1) [EPA/ROD/R08-91/045];
- Chemical Sales (OU2) [EPA/ROD/R08-91/046];
- Marshall Landfill [EPA/ROD/R08-86/008];
- Martin Marietta, Denver Aerospace [EPA/ROD/R08-90/035];
- Rocky Mountain Arsenal (OU17) [EPA/ROD/R08-90/037];
- Rocky Mountain Arsenal (OU18) [EPA/ROD/R08-90/038]; and
- Rocky Mountain Arsenal (OU19) [EPA/ROD/R08-039].

The 1986 ROD for Marshall Landfill specified ground water cleanup standards for tetrachloroethene and trichloroethene of zero. These zero cleanup standards are not technically achievable and demonstration of compliance with a zero standard is impossible. Therefore, the 1986 Marshall Landfill ROD was not included in the evaluation.

5.3.5 Selected Remediation Targets for Ground Water

As discussed in Section 5.1.5, the NCP states that preliminary remediation goals are to be developed based on readily available information, such as chemical-specific ARARs. As such, remediation targets selected for ground water are based on ARARs and TBCs. The remediation targets for ground water are consistent with cleanup standards established for other Colorado NPL sites, and can be distinguished from background levels. As such, the selected remediation targets were deemed to be appropriate for the purpose of developing remedial alternatives and for determining the feasibility of remediating contaminated ground water.

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APPENDIX A

EXPOSURE FACTORS USED FOR CALCULATING THE PRELIMINARY RISK-BASED REMEDIATION GOALS

TABLE 1
EXPOSURE FACTORS FOR SOIL/DUST INGESTION

FACTORS FOR POTENTIALLY COMPLETE ROUTES OF EXPOSURE		Resident	Office Worker	Construction Worker	Ecological Worker	Gravel Mine Worker
Ingestion Rate	RME ☞	200 [1,3]	NA	NA	NA	NA
Child (mg/day)	CT ☞	100 [2,4]	NA	NA	NA	NA
Ingestion Rate	RME ☞	100 [3]	50 [3]	480 [3]	50 [3]	50 [13]
Adult (mg/day)	CT ☞	50 [4]	5 [5]	95 [6]	15 [5,7]	10 [13]
Exposure Frequency	RME ☞	350 [3]	250 [3]	30 [3]	65 [3]	250 [14]
(days/yr)	CT ☞	245 [8]	219 [4]	30 [3]	65 [3]	219 [14]
Exposure Duration	RME ☞	6 / 24 [3]	25 [3]	1 [3]	2.5 [3]	25 [15]
Child/Adult (years)	CT ☞	2 / 7 [9]	4 [10]	1 [3]	2.5 [3]	4 [15]
Body Weight	RME ☞	15 / 70 [3]	70 [3]	70 [3]	70 [3]	70 [16]
Child/Adult (kg)	CT ☞	15 / 70 [3]	70 [3]	70 [3]	70 [3]	70 [16]
Averaging Time - Child/Adult:	RME ☞	2190 / 8760	9125	365	915	9125
Non-carcinogen (days) [11]	CT ☞	730 / 2555	1460	365	915	1460
Averaging Time:	RME ☞	25550	25550	25550	25550	25550
Carcinogen (days) [12]	CT ☞	25550	25550	25550	25550	25550

NOTES:

(NA) Not applicable; only an adult exposure was assessed for exposure pathway.

(1) Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum Exposure (RME) risks in a baseline or remediation risk assessment. RME risks are derived using professional judgment to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others set at Central Tendency (CT) values in order to characterize the high-end risks to a very small proportion of an exposed population.

(2) Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst

case" when used in combination with selected high-end values).

Average risks are derived using professional judgment to set all exposure parameters at 50th percentile (median) or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) Final Rocky Flats Programmatic Risk-Based Preliminary Remediation Goals, DOE, 1994.

(4) Preliminary CT default value (EPA, 1993).

(5) Average of CT soil ingestion rates of 15 mg/day (outdoor industrial worker) and 5 mg/day (indoor industrial worker) based on inferences drawn from Finley and Paustenbach, 1994. Soil ingestion rates for workers indoors (e.g., office workers) are one-half the average of workers both indoors and outdoors (e.g., industrial workers).

(6) Estimated using HE ingestion rate ratio of construction worker to industrial worker (480/50 = 9.6; CT = 9.6 x 10 mg/day), but a more defensible CT default is 40.

(7) Three times the office worker based on inferences drawn from Finley and Paustenbach, 1994; soil ingestion rates for workers outdoors (e.g., ecological workers) are three times the rates for workers indoors (e.g., office workers).

(8) Average of two exposure frequencies: outdoor soil/dust CT value of 150 days (Finley and Paustenbach, 1994) and indoor dust CT value of 335 days, assuming 15 days of vacation travel and 15 days of employment travel or overnight visits.

(9) Preliminary CT default values, adding to 9 years total exposure duration (EPA, 1993).

(10) American Industrial Health Council, 1994; Gephart, Tell, and Triemer, 1994.

(11) Exposure duration (years) x 365 days (EPA RAGS, HHEM Part A, 1989).

(12) Lifetime exposure (70 years) x 365 days (EPA RAGS HHEM Part A, 1989).

(13) RME: RAGS, HHEM, Standard Default Exposure Factors, (EPA, 1991). CT: Inferred from Finley and Paustenbach, 1994; average of CT soil ingestion rates of 15 mg/day (outdoor industrial worker) and 5 mg/day (indoor industrial worker).

(14) RME: RAGS, HHEM, Standard Default Exposure Factors (EPA, 1991). CT: Preliminary default value (EPA, 1993).

(15) RME: RAGS, HHEM, Standard Default Exposure Factors (EPA, 1991). CT: American Industrial Health Council (1994).

(16) RAGS, HHEM, Standard Default Exposure Factors (EPA, 1991).

TABLE 2
EXPOSURE FACTORS FOR SOIL/DUST INHALATION

FACTORS FOR POTENTIALLY COMPLETE ROUTES OF EXPOSURE		Resident	Office Worker	Construction Worker	Ecological Worker	Gravel Mine Worker
Inhalation Rate (m^3/hr)	RME ☞	0.83 [1,3]	0.83 [3]	1.25 [3]	0.83 [3]	0.83 [13]
	CT ☞	0.63 [2,4]	0.63 [3,5]	1.25 [3]	0.83 [3]	0.83 [13]
Exposure Time (hr/day)	RME ☞	24 [3]	8 [3]	8 [3]	8 [3]	12 [14]
	CT ☞	15 [6]	7.2 [7]	7.2 [7]	7.2 [8]	10 [14]
Exposure Frequency (days/yr)	RME ☞	350 [3]	250 [3]	30 [3]	65 [3]	250 [15]
	CT ☞	245 [8]	219 [8]	30 [3]	65 [3]	219 [15]
Exposure Duration (years)	RME ☞	30 [3]	25 [3]	1 [3]	2.5 [3]	25 [16]
	CT ☞	9 [9]	4 [10]	1 [3]	2.5 [3]	4 [16]
Body Weight (kg)	RME ☞	70 [3]	70 [3]	70 [3]	70 [3]	70 [13]
	CT ☞	70 [3]	70 [3]	70 [3]	70 [3]	70 [13]
Averaging Time: Non-carcinogen (days) [12]	RME ☞	10950	9125	365	915	9125
	CT ☞	3285	1460	365	915	1460
Averaging Time: Carcinogen (days) [13]	RME ☞	25550	25550	25550	25550	25550
	CT ☞	25550	25550	25550	25550	25550

NOTES:

(1) Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum Exposure (RME) risks in a baseline or remediation risk assessment. RME risks are derived using professional judgment to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others set at Central Tendency (CT) values in order to characterize the high-end risks to a very small proportion of an exposed population.

(2) Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst case" when used in combination with selected high-end values). Average risks are derived using professional judgment to set all exposure parameters at

50th percentile (median) or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) Final Rocky Flats Programmatic Risk-Based Preliminary Remediation Goals, DOE 1994.

(4) CT residential inhalation rate (adult) based on EPA RAGS, HHEM Part B, 1991a.

(5) CT worker inhalation rate of 0.63 m^3/hr (adult indoors) based on EPA Exposure Factors Handbook, 1989a.

(6) Based on average time spent at home (0.64 adult) (American Industrial Health Council, 1994; Gephart, Tell and Triemer, 1994).

(7) Based on average time spent at work (36 hr/wk) (American Industrial Health Council, 1994; Gephart, Tell and Triemer, 1994).

(8) Preliminary CT default value (EPA, 1993).

(9) Preliminary CT default value (EPA, 1993).

(10) American Industrial Health Council, 1994; Gephart, Tell and Triemer, 1994.

(11) Exposure duration (years) x 365 days (EPA RAGS, HHEM Part A, 1989.)

(12) Lifetime exposure (70 years) x 365 days (EPA RAGS, HHEM Part A, 1989).

(13) RAGS, HHEM, Standard Default Exposure Factors (EPA, 1991).

(14) Mining Exposure Scenario for Baseline Risk Assessments at the Rocky Flats Environmental Technology Site (DOE, 1994a).

(15) RME: RAGS, HHEM, Standard Default Exposure Factors (EPA, 1991). CT: Preliminary default value (EPA, 1993).

(16) RME: RAGS, HHEM, Standard Default Exposure Factors (EPA, 1991). CT: American Industrial Health Council (1994).

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TABLE 3
EXPOSURE FACTORS FOR GROUNDWATER INGESTION

FACTORS FOR POTENTIALLY COMPLETE ROUTES OF EXPOSURE		Resident	Office Worker	Construction Worker	Ecological Worker	Gravel Mine Worker
Ingestion Rate	RME ☞	2.0 [1,3]	NA	NA	NA	NA
(L/day)	CT ☞	1.4 [2,4]	NA	NA	NA	NA
Exposure Frequency	RME ☞	350 [3]	NA	NA	NA	NA
(days/yr)	CT ☞	335 [5]	NA	NA	NA	NA
Exposure Duration	RME ☞	30 [3]	NA	NA	NA	NA
(years)	CT ☞	9 [6]	NA	NA	NA	NA
Body Weight	RME ☞	70 [3]	NA	NA	NA	NA
(kg)	CT ☞	70 [3]	NA	NA	NA	NA
Averaging Time:	RME ☞	10950	NA	NA	NA	NA
Non-carcinogen (days) [7]	CT ☞	3285	NA	NA	NA	NA
Averaging Time:	RME ☞	25550	NA	NA	NA	NA
Carcinogen (days) [8]	CT ☞	25550	NA	NA	NA	NA

NOTES:

(NA) Not applicable; only residential exposure pathway considered in analysis.

(1) Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum Exposure (RME) risks in a baseline or remediation risk assessment. RME risks are derived using professional judgment to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others set at Central Tendency (CT) values in order to characterize the high-end risks to a very small proportion of an exposed population.

(2) Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst case" when used in combination with selected high-end values). Average risks are derived using professional judgment to set all exposure parameters at 50th percentile (median) or mean values in order to

characterize the mid-range risk to the largest proportion of an exposed population.

(3) Final Rocky Flats Programmatic Risk-Based Preliminary Remediation Goals, DOE, 1994.

(4) HE and CT adult total water-based beverage intakes, including tap water (EPA Exposure Factors Handbook, 1989a).

(5) Assuming 15 days of vacation travel and 15 days of employment travel.

(6) Preliminary CT default value (EPA, 1993).

(7) Exposure duration (years) x 365 days (EPA RAGS, HHEM Part A, 1989).

(8) Lifetime exposure (70 years) x 365 days (EPA RAGS, HHEM Part A, 1989).

TABLE 4
EXPOSURE FACTORS FOR GROUNDWATER AND SUBSOIL VOC INHALATION *

FACTORS FOR POTENTIALLY COMPLETE ROUTES OF EXPOSURE		Resident	Office Worker	Construction Worker	Ecological Worker	Gravel Mine Worker
Inhalation Rate (m^3/hr)	RME ☞	0.63 (1,3)	0.83 (3)	1.25 (3)	NA	NA
	CT ☞	0.63 (2,6)	0.63 (4)	1.25 (3)	NA	NA
Exposure Time (hr/day)	RME ☞	24 (3)	8 (3)	8 (3)	NA	NA
	CT ☞	15 (7)	7.2 (6)	7.2 (6)	NA	NA
Exposure Frequency (days/yr)	RME ☞	350 (3)	250 (3)	30 (3)	NA	NA
	CT ☞	234 (8)	219 (8)	30 (3)	NA	NA
Exposure Duration (years)	RME ☞	30 (3)	25 (3)	1 (3)	NA	NA
	CT ☞	9 (8)	4 (9)	1 (3)	NA	NA
Body Weight (kg)	RME ☞	70 (3)	70 (3)	70 (3)	NA	NA
	CT ☞	70 (3)	70 (3)	70 (3)	NA	NA
Averaging Time Non-carcinogen (days) (10)	RME ☞	10950	9125	365	NA	NA
	CT ☞	3285	1460	365	NA	NA
Averaging Time Carcinogen (days) (11)	RME ☞	25550	25550	25550	NA	NA
	CT ☞	25550	25550	25550	NA	NA

* Includes *indoor* VOC vapor from household use of a groundwater supply and VOC vapor infiltration from subsoil into homes and offices; also *outdoor* VOC vapor from subsoil excavation at construction sites.

NOTES:

(NA) Not applicable because the exposure pathway is incomplete.

(1) Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum Exposure (RME) risks in a baseline or remediation risk assessment. RME risks are derived using professional judgment to set one or more sensitive exposure parameters at HE (90-98th percentile) values in

combination with others set at Central Tendency (CT) values in order to characterize the high-end risks to a very small proportion of an exposed population.

(2) Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst case" when used in combination with selected high-end values). Average risks are derived using professional judgment to set all exposure parameters at 50th percentile (median) or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) Final Rocky Flats Programmatic Risk-Based Preliminary Remediation Goals, DOE, 1994.

(4) CT worker inhalation rate of 0.63 m^3/hr (adult indoors) based on EPA Exposure Factors Handbook, 1989a.

(5) CT residential inhalation rate (adult indoors) based on EPA RAGS, HHEM, Standard Default Exposure Factors, 1991.

(6) Based on average time spent at work (36 hr/wk) (American Industrial Health Council, 1994; Gephart, Tell and Triemer, 1994).

(7) Based on average time spent at home (0.64 adult; 0.82 child) (American Industrial Health Council, 1994; Gephart, Tell and Triemer, 1994).

(8) Preliminary CT default value (EPA, 1993).

(9) American Industrial Health Council, 1994; Gephart, Tell and Triemer, 1994.

(10) Exposure duration (years) x 365 days (EPA RAGS, HHEM Part A, 1989).

(11) Lifetime exposure (70 years) x 365 days (EPA RAGS, HHEM Part A, 1989).

TABLE 5
EXPOSURE FACTORS FOR EXTERNAL RADIATION

FACTORS FOR POTENTIALLY COMPLETE ROUTES OF EXPOSURE		Resident	Office Worker	Construction Worker	Ecological Worker	Gravel Mine Worker
Gamma Exposure	RME ☞	1.0 [1,3]	0.3 [3]	0.3 [3]	0.3 [3]	0.3 [11]
Time Factor (Te)	CT ☞	0.75 [2,5]	0.3 [4]	0.3 [4]	0.3 [4]	0.3 [11]
Gamma Shielding	RME ☞	0.8 [6]	0.8 [6]	0.8 [6]	0.8 [6]	0.8 [12]
Factor (1-Se)	CT ☞	0.5 [7]	0.5 [7]	0.8 [8]	0.8 [8]	0.8 [12]
Exposure Frequency	RME ☞	350 [3]	250 [3]	30 [3]	65 [3]	250 [13]
(days/yr)	CT ☞	234 [9]	219 [9]	30 [3]	65 [3]	219 [13]
Exposure Duration	RME ☞	30 [3]	25 [3]	1 [3]	2.5 [3]	25 [14]
(years)	CT ☞	9 [9]	4 [10]	1 [3]	2.5 [3]	4 [14]

NOTES:

(1) Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum Exposure (RME) risks in a baseline or remediation risk assessment. RME risks are derived using professional judgment to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others set at Central Tendency (CT) values in order to characterize the high-end risks to a very small proportion of an exposed population.

(2) Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst case" when used in combination with selected high-end values). Average risks are derived using professional judgment to set all exposure parameters at 50th percentile (median) or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) Final Rock Flats Programmatic Risk-Based Preliminary Remediation Goals, DOE, 1994.

(4) Assuming the HE fraction of time exposed (8 out of 24 hours or 0.33) according to EPA RAGS, HHEM Part B - Revised (Dinan, 1992).

(5) Assuming the CT fraction of time spent at home (average of adult - 0.64 and child - 0.82) (American Industrial Health Council, 1994; Gephart, Tell and Triemer, 1994).

(6) Standard default screening value specified in EPA RAGS, HHEM Part B, 1991b (1 - 0.2 = 0.8), assuming substantial time shielded by structures.

(7) Estimated typical value for residents and indoor workers shielded by buildings (DOE documents for RFP, such as "Mining Exposure Scenario for Baseline Risk Assessments at the Rocky Flats Environmental Technology Site" (DOE, 1994a).

(8) Assumed typical value for outdoor workers with only limited shielding indoors.

(9) Preliminary CT default value (EPA, 1993).

(10) American Industrial Health Council, 1994; Gephart, Tell and Triemer, 1994.

(11) EPA RAGS, HHEM Part B - Revised (Dinan, 1992).

(12) RAGS, HHEM Part B (EPA, 1991a); assuming limited time shielded by structures.

(13) RME: RAGS, HHEM, Standard Default Exposure Factors (EPA, 1991). CT: Preliminary default value (EPA, 1993).

(14) RME: RAGS, HHEM, Standard Default Exposure Factors (EPA, 1991). CT: American Industrial Health Council (1994).

Finley, et. al. 1994. *The Benefits of Probabilistic Exposure Assessment: Three Case Studies Involving Contaminated Air, Water, and Soil.* Risk Analysis 14(1): 53 - 73

Gephart, et. al. 1994. *Exposure Factors Manual.* Journal of Soil Contamination. 3(1): 47 - 117

APPENDIX B

CONTAMINANT-SPECIFIC TOXICITY INFORMATION

APPENDIX B
CONTAMINANT-SPECIFIC TOXICITY INFORMATION*

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor $(mg/kg-day)^{-1}$	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor $(mg/kg-day)^{-1}$	External Slope Factor (risk/yr per pCi/g)	Henry's Law Constant ($atm-m^3/mol$)	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
Aroclor-1254	-	7.70E+00	-	-	-	1.07E-03 f	530000 f		0.05571
Aroclor-1260	-	7.70E+00	-	-	-	1.07E-03 f	530000 f		0.05571
Arsenic	3.00E-04	1.75E+00 c	-	1.51E+01	-	-			
bis(2-Ethylhexyl)phthalate	2.00E-02	1.40E-02	-	-	-	1.00E-04	10000		
Cadmium	5.00E-04	-	-	6.30E+00	-	-			
Carbon tetrachloride#	7.00E-04	1.30E-01	-	5.25E-02	-	2.41E-02 f	110 f	7.57E+02 f	0.08451 g
Chloroform#	1.00E-02	6.10E-03	-	8.05E-02	-	2.87E-03 f	31 f	8.20E+03 f	0.09404 g
Chromium III	1.00E+00	-	-	-	-	-			
1,1-Dichloroethene#	9.00E-03	6.00E-01	-	1.75E-01	-	3.40E-02 f	65 f	2.25E+03 f	0.08386 g
Mercury	3.00E-04 b	-	8.40E-05 d	-	-	-			
Methylene chloride#	6.00E-02	7.50E-03	8.57E-01	1.64E-03	-		48		
Tetrachloroethene#	1.00E-02	5.20E-02 e	-	2.03E-03	-	2.59E-02 f	364 f		0.07852 g
Trichloroethene#	-	1.10E-02	-	5.95E-03	-	9.10E-03 f	126 f	1.10E+03 f	0.08606 g
Vinyl Chloride#	-	1.90E+00 b	-	3.00E-01 b	-	8.19E-02 f	57 f	2.67E+03 f	1.14E-01 g
Americium-241	-	2.40E-10 b*	-	3.20E-08 b*	4.90E-09 b				
Plutonium-239	-	2.30E-10 b*	-	3.80E-08 b*	1.70E-11 b				
Plutonium-240	-	2.30E-10 b*	-	3.80E-08 b*	2.70E-11 b				
Uranium-233	-	1.60E-11 b*	-	2.70E-08 b*	4.20E-11 b				
Uranium-234	-	1.60E-11 b*	-	2.60E-08 b*	3.00E-11 b				
Uranium-235+D	-	1.60E-11 b*	-	2.50E-08 b*	2.40E-07 b				
Uranium-238+D	-	2.00E-11 b*	-	2.40E-08 b*	5.10E-08 b				

= Chemicals listed are volatile.

* = Values given are in risk/yr per pCi/g.

** = Values given are in units of pCi/L.

*** = Values given are in units of pCi/g.

a = All toxicity values are from IRIS, February 1994 unless otherwise noted.

b = Value from HEAST, 1993.

c = Value given for arsenic is calculated from an oral unit risk of 5E-5 ($L/\mu g$).

d = Values given for chemicals were calculated from HEAST.

e = Values given for tetrachloroethene are from a U.S. EPA memo from the Office of Research and Development Environmental Criteria and Assessment Office.

f = Values given are found in the Superfund Public Health Evaluation Manual, 1986.

g = Values given are found in the Superfund Exposure Assessment Manual, 1988.

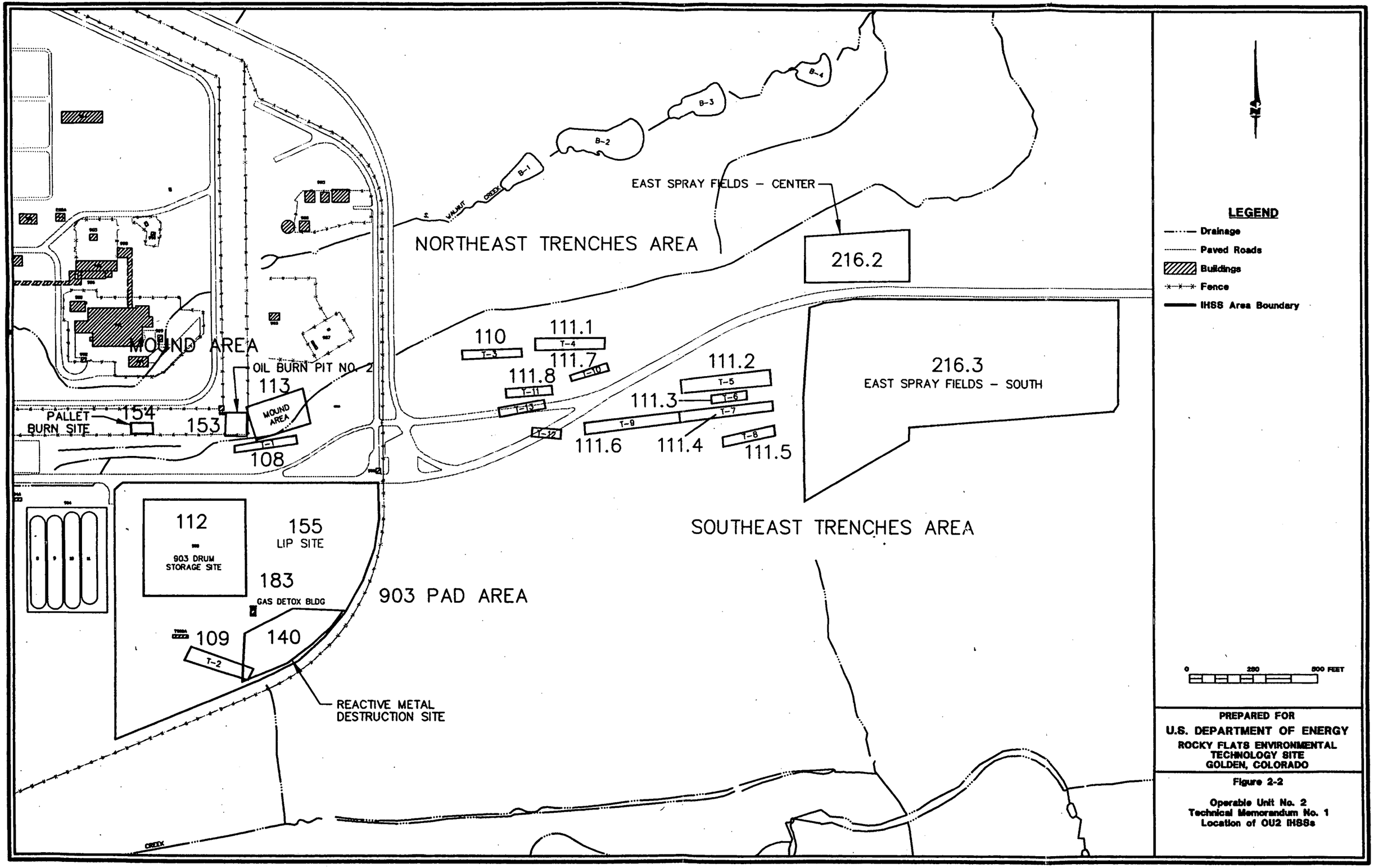
B-4
B-3
B-2
B-1
WALNUT CREEK
EAST SPRAY FIELDS – CENTER
NORTHEAST TRENCHES AREA
216.2
MOUND AREA
OIL BURN PIT NO. 2
113
MOUND AREA
PALLET BURN SITE
154
153
108
110
T-3
111.1
T-4
111.7
T-10
111.8
T-11
T-13
T-12
111.2
T-5
T-6
111.3
T-7
T-9
111.6
111.4
T-8
111.5
216.3
EAST SPRAY FIELDS – SOUTH
SOUTHEAST TRENCHES AREA
112
903 DRUM STORAGE SITE
155
LIP SITE
183
GAS DETOX BLDG
903 PAD AREA
109
140
T-2
REACTIVE METAL DESTRUCTION SITE
CREEK
LEGEND
Drainage
Paved Roads
Buildings
Fence
IHSS Area Boundary
0
250
500 FEET
PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO
Figure 2-2
Operable Unit No. 2
Technical Memorandum No. 1
Location of OU2 IHSSs

TABLE 5-2
PRELIMINARY REMEDIATION LEVELS FOR OU2 SURFACE SOIL

Chemical Of Concern	Background Concentration (UTL 99%)	Minimum Detection Limit j/	Potential Chemical Specific ARARs/TBCs		Programmatic Risk-Based PRG										Cleanup Standards Established at Other Colorado NPL Sites	~~Selected~~ → Remediation Targets for OU2	Maximum Concentration Detected at OU2 k/
					Residential				Commercial/Industrial a/				Ecological Researcher				
					RME d/		CT e/		RME d/		CT e/		RME d/		CT e/		
			ARARs	TBCs	NC f/	C g/	NC f/	C g/	NC f/	C g/	NC f/	C g/	NC f/	C g/	NC f/	C g/	
Aroclor-1254 (mg/kg)	0.00E+00 b/	4.40E-02	---	2.50E+01 c/	---	8.32E-02	---	7.38E-01	---	7.43E-01	---	5.30E+01	---	2.86E+01	---	9.52E+01	2.50E+01 ✓	2.50E+01	9.70E-01
Aroclor-1260 (mg/kg)	0.00E+00 b/	4.40E-02	---	2.50E+01 c/	---	8.32E-02	---	7.38E-01	---	7.43E-01	---	5.30E+01	---	2.86E+01	---	9.52E+01	2.50E+01 \	2.50E+01	6.60E-01
Bis (2-ethylhexyl) phthalate (mg/kg)	0.00E+00 b/	3.30E-01	---	---	5.49E+03	4.57E+01	1.46E+04	4.05E+02	4.09E+04	4.09E+02	4.67E+05	2.91E+04	1.57E+05	1.57E+04	5.26E+05	5.24E+04	2.80E+01	4.09E+02	5.10E-01
Chromium III (mg/kg)	2.48E+01	2.00E+00	---	---	2.74E+05	---	7.33E+05	---	>1.00E+06 i/	---	>1.00E+06 i/	---	>1.00E+06 i/	---	>1.00E+06 i/	---	5.60E+01 h/ - 6.00E+01 h/	1.00E+06	2.95E+01
Americium-241 (pCi/g)	6.00E-02	2.00E-02	---	8.52E+02 l/	---	2.37E+00	---	2.04E+01	---	9.55E+00	---	2.49E+02	---	2.04E+02	---	2.83E+02	---	8.52E+02	1.60E+02
Plutonium-239/240 (pCi/g)	1.33E-01	3.00E-02	---	1.80E+03 l/	---	3.42E+00	---	3.20E+01	---	1.38E+01	---	9.47E+02	---	5.28E+02	---	1.71E+03	---	1.80E+03	7.30E+03

NOTES
a/ Commercial/industrial exposure is based on an office worker exposure scenario.
b/ Background concentration for organic compounds is assumed to be zero.
c/ TSCA [see 40 CFR 761.120 and 761.125].
d/ RME PRG is based on reasonable maximum exposure factors.
e/ CT PRG is based on central tendency exposure factors.
f/ NC PRG is based on noncarcinogenic toxicity information.
g/ C PRG is based on carcinogenic toxicity information.
h/ Represents total chromium value.
i/ RME and CT PRG values exceed 10^6 parts per million.
j/ MDLs originate from the General Radiochemistry and Routine Analytical Services Protocol (EG&G, 1991, and EG&G, 1991a).
k/ Maximum concentrations originate from Technical Memorandum No. 9 (DOE, 1994a).
l/ Radionuclide value based on RME office worker exposure pathway only.

TARGET for SCREENING ALTERNATIVES

For Selected AREAS - Industrial Area

Carl - Cumulative EFFECT - in detailed Analysis

SEE 8848 NCP (ii) RAO

10^{-4} is generally accepted

IS The ARAR sufficiently protective

25

TABLE 5-3
PRELIMINARY REMEDIATION LEVELS FOR OU2 SUBSURFACE SOIL

Chemical Of Concern	Background Concentration (UTL 99%)	Minimum Detection Limit k/	Potential Chemical Specific ARARs/TBCs a/		Programmatic Risk-Based PRG b/								Cleanup Standards Established at Other Colorado NPL Sites	Selected Remediation Targets for OU2	Maximum Concentration Detected at OU2 l/
					Gravel Miner Exposure Scenario				Construction Worker Exposure Scenario						
					RME e/		CT f/		RME e/		CT f/				
			ARARs	TBCs	NC g/	C h/	NC g/	C h/	NC g/	C h/	NC g/	C h/			
Arsenic (mg/kg)	1.70E+01	2.00E+00	---	---	6.13E+02	3.27E+00	3.50E+03	1.16E+02	5.32E+02	7.09E+01	2.69E+03	3.58E+02	5.00E+00 - 7.90E+01	7.09E+01	3.08E+01
Cadmium (mg/kg)	2.00E+00	1.00E+00	---	---	1.02E+03	2.11E+04	5.83E+03	1.81E+05	8.87E+02	>1.00E+06 i/	4.48E+03	>1.00E+06 i/	3.20E+00	8.87E+02	1.05E+01
Mercury (mg/kg)	2.10E+00	2.00E-01	---	---	6.13E+02	---	3.50E+03	---	5.32E+02	---	2.69E+03	---	3.70E+00 d/	5.32E+02	1.14E+02
Tetrachloroethene (mg/kg)	0.00E+00 c/	5.00E+00	---	---	2.04E+04	6.46E+01	1.17E+05	1.00E+03	1.77E+04	2.22E+03	8.96E+04	9.04E+03	1.90E+00	2.22E+03	1.30E+04
Americium-241 (pCi/g)	2.00E-02	2.00E-02	---	7.95E+02 m/	---	9.45E+00	---	1.46E+02	---	2.16E+02	---	5.37E+02	---	7.95E+02	2.20E+01
Plutonium-239/240 (pCi/g)	2.50E-02	3.00E-02	---	1.57E+03 m/	---	1.38E+01	---	4.76E+02	---	3.01E+02	---	1.51E+03	---	1.57E+03	1.80E+02
Uranium-233/234 (pCi/g)	3.44E+00	3.00E-01	---	4.93E+04 m/	---	1.78E+02	---	4.49E+03	---	4.13E+03	---	1.75E+04	---	4.93E+04	1.92E+02
Uranium-235 j/ (pCi/g)	1.53E-01	3.00E-01	---	2.55E+02 m/	---	6.92E-01	---	4.34E+00	---	1.73E+01	---	1.73E+01	---	2.55E+02	1.15E+01
Uranium-238 j/ (pCi/g)	1.81E+00	3.00E-01	---	3.93E+03 m/	---	3.20E+00	---	2.03E+01	---	7.98E+01	---	8.13E+01	---	3.93E+03	1.13E+02

NOTES
a/ Chemical-specific ARARs/TBCs have not been identified for the remediation of the potential chemicals of concern for subsurface soil.
b/ PRG values are based on commercial/industrial exposure utilizing both the gravel miner and construction worker scenarios; residential and ecological worker receptors are not included in the programmatic exposure scenarios.
c/ Background concentrations for organic compounds is assumed to be zero.
d/ Value is based on results of the TCLP test (mg/l).
e/ RME PRG based on reasonable maximum exposure factors.
f/ CT PRG based on central tendency exposure factors.
g/ NC PRG based on noncarcinogenic toxicity information.
h/ C PRG based on carcinogenic toxicity information.
i/ RME and CT PRG values exceed 10^6 parts per million.
j/ PRG values included daughter products; unless otherwise noted.
k/ MDLs originate from the General Radiochemistry and Routine Analytical Services Protocol (EG&G, 1991, and EG&G, 1991a).
l/ Maximum concentrations originate from Technical Memorandum No. 9 (DOE, 1994a).
m/ Radionuclide value based on RME construction worker exposure pathway.

TABLE 5-4
PRELIMINARY REMEDIATION LEVELS FOR OU2 UHSU GROUND WATER

Chemical of Concern (Units as Indicated)	Background Concentration ($UTL_{95/95}$)	Minimum Detection Limit [y]	Potential Chemical-Specific ARARs/TBCs		Programmatic Risk-Based PRG Residential Exposure Scenario [d]				Cleanup Standards Established at Other Colorado NPL Sites	Selected Remediation Targets for OU2	Maximum Concentration Detected at OU2 [z]
			ARARs	TBCs	RME [o]		CT [v]				
					NC [w]	C [x]	NC [w]	C [x]			
Carbon Tetrachloride (ug/L)	0.00E+00 [w]	5.00E+00	1.00E+00 [c] 5.00E+00 [u]	—	2.55E+01	2.60E-01	3.81E+01	1.37E+00	5.00E+00	1.00E+00	2.00E+04
Chloroform (ug/L)	0.00E+00 [w]	5.00E+00	6.00E+00 [c] 1.00E+02 [u]	—	3.65E+02	2.76E-01	5.45E+02	1.52E+00	1.00E+02	6.00E+00	3.90E+04
1,1-Dichloroethene (ug/L)	0.00E+00 [w]	5.00E+00	7.00E+00 [u,aa]	—	3.28E+02	6.77E-02	4.90E+02	3.54E-01	7.00E+00	7.00E+00	3.80E+02
Methylene Chloride (ug/L)	0.00E+00 [w]	5.00E+00	5.00E+00 [u,aa]	—	1.73E+03	6.22E+00	2.22E+03	3.23E+01	4.80E+00 - 1.00E+01	5.00E+00	3.50E+04
Tetrachloroethene (ug/L)	0.00E+00 [w]	5.00E+00	5.00E+00 [u, cc]	—	3.65E+02	1.43E+00	5.45E+02	7.16E+00	5.00E+00 - 1.00E+01	5.00E+00	1.40E+04
Trichloroethene (ug/L)	0.00E+00 [w]	5.00E+00	5.00E+00 [u, cc]	—	—	2.55E+00	—	1.36E+01	5.00E+00	5.00E+00	1.50E+05
Vinyl Chloride (ug/L)	0.00E+00 [w]	1.00E+01	2.00E+00 [u,aa]	—	—	2.81E-02	—	1.45E-01	2.00E+00	2.00E+00	8.60E+02
Americium-241 (pCi/L)	3.70E-2	1.00E-02	—	3.00E+01 [q]	—	1.98E-01	—	9.87E-01	3.00E+01	3.00E+01	4.65E+01
Plutonium-239/240 (pCi/L)	6.40E-02	1.00E-02	—	3.00E+01 [q]	—	2.07E-01	—	1.03E+00	3.00E+01	3.00E+01	3.55E+02

NOTES:

[a] Values are based on Federal Maximum Contaminant Levels (40 CFR 141 and 142) which are identical to state standards contained in 5 CCR 1003-1. Value for chloroform is based on the sum of all trihalomethanes (i.e., bromodichloromethane, dibromochloromethane, boroform, and chloroform).
[w] Background concentration for organic compounds is assumed to be zero.
[c] Colorado Statewide Standard for Ground Water (5 CCR 1002-8, Section 3.11). All organic values are interim standards.
[q] Derived Concentration Guidelines from DOE Order 5400.5, Chapter III; based on 100 mrem radiation dose for members of the public. Values are for ground water pathway only.
[d] PRG values based on residential exposure scenario only, commercial/industrial and ecological worker receptors not included in programmatic exposure scenarios.
[o] RME PPRG based on reasonable maximum exposure factors.
[v] CT PRG based on central tendency exposure factors.
[w] NC PRG based on noncarcinogenic toxicity information.
[x] C PRG based on carcinogenic toxicity information.
[y] MDLs originate from the General Radiochemistry and Routine Analytical Services Protocol (EG&G, 1991 and EG&G, 1991a).
[z] Maximum concentrations originate from Technical Memorandum No. 9 (DOE, 1994a).

Site Specific Colorado Standards not ARAR??

Bonnie, RME to define Risk Based